

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
14 July 2005 (14.07.2005)

PCT

(10) International Publication Number
WO 2005/064666 A1

(51) International Patent Classification⁷: **H01L 21/465**,
29/06, 29/20, 33/00

(21) International Application Number:
PCT/US2003/039211

(22) International Filing Date: 9 December 2003 (09.12.2003)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant (for all designated States except US): **THE REGENTS OF THE UNIVERSITY OF CALIFORNIA** [US/US]; 1111 Franklin Street, 12th Floor, Oakland, CA 94607 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **FUJII, Tetsuo** [JP/US]; 7240 Davenport Road, #104, Goleta, CA 93117 (US). **GAO, Yan** [CN/US]; 705 Bolton Walk, #102, Goleta, CA 93117 (US). **HU, Evelyn, L.** [US/US]; 1160 North Fairview Avenue, Goleta, CA 93117 (US). **NAKA-MURA, Shuji** [JP/US]; P.O. Box 61656, Santa Barbara, CA 93160 (US).

(74) Agent: **GATES, George, H.**; Gates & Cooper LLP, 6701 Center Drive West, Suite 1050, Los Angeles, CA 90045 (US).

(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (regional): ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:

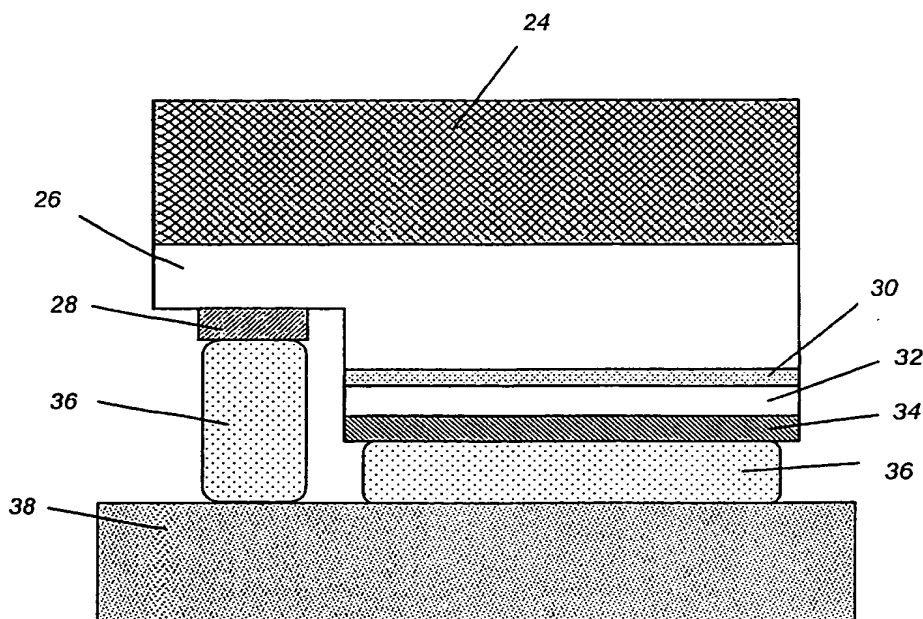
— of inventorship (Rule 4.17(iv)) for US only

Published:

— with international search report

[Continued on next page]

(54) Title: **HIGHLY EFFICIENT GALLIUM NITRIDE BASED LIGHT EMITTING DIODES VIA SURFACE ROUGHENING**



(57) Abstract: A gallium nitride (GaN) based light emitting diode (LED), wherein light is extracted through a nitrogen face (N-face) (42) of the LED and a surface of the N-face (42) is roughened into one or more hexagonal shaped cones. The roughened surface reduces light reflections occurring repeatedly inside the LED, and thus extracts more light out of the LED. The surface of the N-face (42) is roughened by an anisotropic etching, which may comprise a dry etching or a photo-enhanced chemical (PEC) etching.



— with amended claims

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.